TÜBİTAK

Turkish Journal of Zoology

http://journals.tubitak.gov.tr/zoology/

Research Article

Turk J Zool
(2021) 45: 570-578
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doi:10.3906/zoo-2104-7

The ichthyofaunal diversity of freshwater ecosystems in Gökçeada Island (NW Turkey) under the pressure of nonnative species

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Received: 05.04.2021 • **Accepted/Published Online:** 05.10.2021 • **Final Version:** 15.11.2021

Abstract: Freshwater ecosystems have a greater value for biodiversity per surface area than terrestrial and marine ecosystems. Streams and lakes are notably prone to biodiversity loss, being the greatest threats habitat destructions and nonnative species. The aim of the present study is to assess the fish composition of lotic and lentic water systems of an island ecosystem (Gökçeada Island, Turkey), which is poorly studied, and to highlight the entry routes and possible impacts of translocated fish species in an island ecosystem. The field surveys were conducted in a total of 14 sampling sites (five reservoirs and nine streams) in the inland waters of Gökçeada Island between September 2019 and January 2021. Fish samples were collected by electrofishing (SAMUS 1000; a backpack electro-shocker). A total of eight fish species belonging to six families (Anguillidae, Atherinidae, Cyprinidae, Leuciscidae, Mugilidae, and Poeciliidae) were determined. As a result fish community of the island was mostly composed by the introduced species *Carassius gibelio*, *Gambusia holbrooki* and *Pseudorasbora parva*. This study provides the first detailed information on the distribution of the fish species encountered in the inland waters of Gökçeada Island. Results showed that the fish fauna of the island was predominantly shaped by fish stocking activities.

Key words: Insular ecosystem, invasive fish, inland waters, species diversity, introductions

1. Introduction

Freshwater ecosystems are considered to be one of the most significant hotspots for biological diversity in the world (Strayer and Dudgeon, 2010). Moreover, these ecosystems are known to be among the most endangered because the extinction threats are considerably greater than those occurring in terrestrial and marine habitats. Freshwater fish is of great interest due to the high level of biodiversity and endemism in the world (Olden et al., 2010). The ichthyofauna of Turkey is distinguished from the European in regard to high species diversity and level of endemism (Balık, 1995). Geographic isolation, in conjunction with the climatic factors and river basin disintegration experienced by Anatolia in the geological period, caused the differentiation of the freshwater fish fauna into various distinct and isolated populations (Özdemir et al., 2015).

Island habitats are very distinctive for their biological diversity, physical environment and threats by several natural and anthropogenic pressures (Velmurugan, 2018). Furthermore, these unique ecosystems contribute to high biodiversity and specialized fauna and flora (MacArthur and Wilson, 1967). With the progress of time, the isolated islands exert distinct evolutionary functions that affect the development of a unique genetic structure and the occurrence of highly specialized species with new features and the emergence of extraordinary adaptations. Likewise, species variety on islands has also yielded important hints into ecological and evolutionary processes (Witt and Maliakal-Witt, 2007). Consequently, since islands are isolated from the mainland, they can be used as natural experimental regions principally to observe the changes in flora and fauna (Velmurugan, 2018).

Gökçeada (Imbros) is the largest island of Turkey, with an area of 290 km^2; has a 95 km coastline located in the northern Aegean Sea, and it is located at the entrance of Saros Bay. The island is not subjected to harsh ecological

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and climatic factors, because of its distance to the mainland, for this reason, it provides a better environment for both vertebrates and invertebrates according to the mainland (Perçin-Paçal et al., 2017). Several studies have been conducted on the marine fish fauna of Gökçeada Island (e.g., Keskin and Ünsal 1998; Keskin, 2004; Türetken, 2009; Akmirza, 2013; Gönülal and Güreşen, 2014; Çoker and Akyol, 2018; Altın et al., 2020). However, few studies have been conducted in the inland waters of Gökçeada (Ulutürk et al., 1986; Balık and Ustaoğlu 1993; Bakaç et al., 2017; Aslan et al., 2018). A recent study has reported a new occurrence of the invasive fish, topmouth gudgeon *Pseudorasbora parva* (Temminck and Schlegel, 1846) that may threaten the inland water ecosystem of Gökçeada Island (Bakaç et al., 2017). The threat posed by invasive species is one of the main problems of biodiversity loss and it is increasing as the number of nonnative species reaching countries around the world is increasing (Seebens et al., 2017). Furthermore, islands are notably more vulnerable to bioinvasions (Jeschke, 2008).

Given the gaps in knowledge on the freshwater fish fauna of Gökçeada Island, the objectives of the present study are to assess the fish presence in the lotic and lentic systems, and to highlight the entry routes and possible impacts of invasive fish species in an island ecosystem (Gökçeada Island, Turkey).

2. Materials and methods

The field surveys were conducted in a total of 14 sampling sites (five reservoirs and nine streams) covering the inland waters of Gökçeada Island (Çanakkale, Turkey). Gökçeada Reservoir, the largest dam on the island, was built on Büyük Stream in 1983 in order to meet the drinking and potable water supply purposes for the island. The other four reservoirs, Aydıncık, Dereköy, Şahinkaya and Uğurlu, are relatively small and were built for irrigation purposes on Değirmen, Ballı, Çıkırım and Uğurlu streams. Uğurlu and Dereköy reservoirs are connected to each other by an irrigation channel. Lotic stations (except Marmaros Stream) have been chosen at the inlet and outlet waters of these reservoirs, as far as site conditions and transportation permit. Fish samples were collected seasonally from the sampling sites with a total of six samplings per each site between September 2019 and January 2021. Data on the sampling sites were listed in Table 1. The map (Figure 1) was created using the QGIS v. 3.4 software available from http://qgis.org.

Fish samples were caught seasonally by electrofishing (SAMUS 1000 portable electro-shocker) in both the lotic and lentic systems of the island due to the insufficient gillnet selectivity in catching small individuals (Saç et al., 2021). In the stream sites, sampling was conducted opposite direction of the water flow from approximately 100 m length of sampling sections. In the reservoirs, fish samples were caught from the shorelines up to 1 m depth. Immediately after capture, fish specimens were anaesthetized with clove oil and then fixed with 5% formalin solution for further investigations. Fish samples were identified based on the keys and descriptions provided by Akşıray (1987) and Kottelat and Freyhof (2007) and counted separately. Each fish sample was measured for standard length (SL) with a digital calliper and recorded to the nearest 1 mm. The relative abundance (N%) of each fish species per sampling site was calculated with the following equation (Kocataş, 2008);

N% = specimen numbers of a taxon (N) / total specimen number of all taxa (total N) × 100.

The frequency of occurrence values of each fish species per sampling site during the entire sampling period was calculated as follows:

F = number of fish catchments containing a fish species / total number of fish samplings.

Table 1. Location of the sampling sites in Gökçeada Island.

Locality No	Locality	Coordinate
1	Gökçeada Reservoir	40.1764556, 25.8640944
2	Tepeköy Stream	40.1769056, 25.8457417
3	Büyük Stream	40.2232861, 25.8954167
4	Aydıncık Reservoir	40.1479028, 25.9264722
5	Değirmen Stream	40.1454472, 25.9480028
6	Şahinkaya Reservoir	40.1154167, 25.7736194
7	Çıkırım Stream-1	40.1366389, 25.7758056
8	Çıkırım Stream-2	40.1064472, 25.7730028
9	Çıkırım Stream-3	40.1011417, 25.7729833
10	Dereköy Reservoir	40.1404639, 25.7370917
11	Ballı Stream-1	40.1569250, 25.7711889
12	Ballı Stream-2	40.1168139, 25.7281889
13	Uğurlu Reservoir	40.1370222, 25.7131917
14	Marmaros Stream	40.1812361, 25.7676917

3. Results

A total of eight fish species (493 specimens) belonging to six families were identified for the inland waters of Gökçeada Island. The number and the length distribution of specimens of each species caught in the sampling sites were shown in Table 2. Fish were captured in nine of 14 sampling stations; whereas, any fish specimen was found to occur in Değirmen, Çıkırım-I, Ballı-I, Ballı-II and Marmaros streams. Most of these streams dry up in the summer. The fish composition of the island is mostly

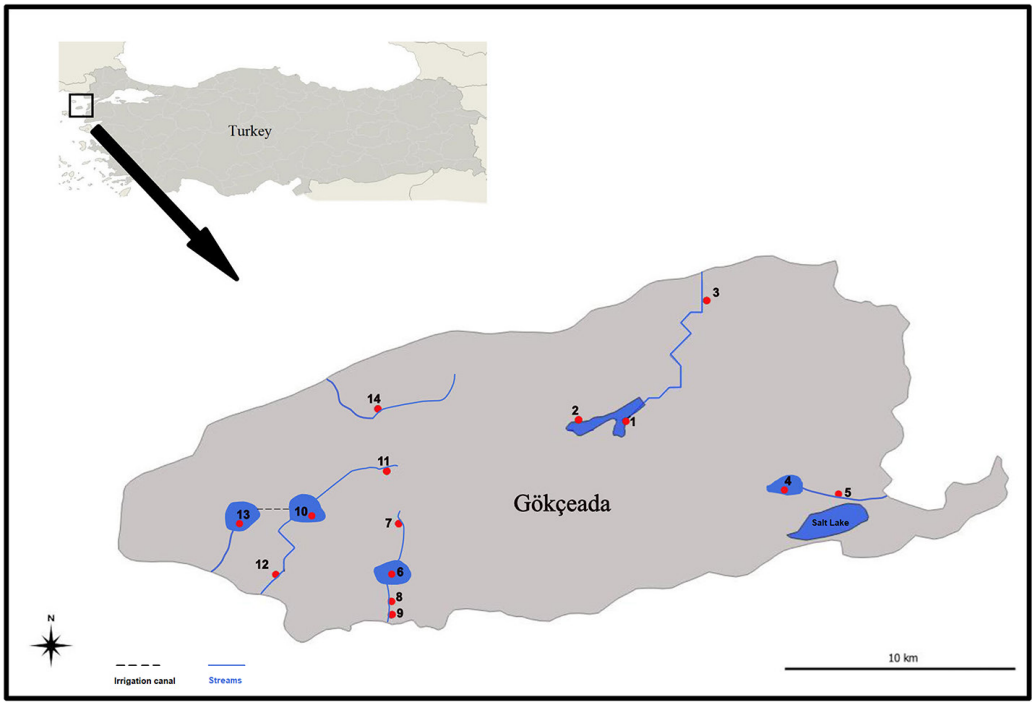

Figure 1. Map of Gökçeada Island with sampling sites.

comprised by introduced species. The site and the date data for each fish species and their sample number and length distribution (minimum-maximum) are listed in detail below.

Family Anguillidae

***Anguilla anguilla* (Linnaeus, 1758)**

Material examined: Station 3, 04.01.2020, 1 individual, 603 mm.

Family Atherinidae

***Atherina boyeri* Risso, 1810**

Material examined: Station 2, 26.05.2020, 2 individuals, 41–53 mm.

Family Cyprinidae

***Cyprinus carpio* Linnaeus, 1758**

Material examined: Station 1, 11.09.2019, 3 ind., 81–161 mm; St. 2, 13.07.2020, 1 ind., 262 mm; Station 4, 11.09.2019, 34 ind., 36–63 mm; St. 4, 24.05.2020, 7 individuals, 26–100 mm; St. 4, 14.07.2020, 6 ind., 21–51 mm; Station 10, 11.09.2019, 26 ind., 33–105 mm; St. 10, 13.07.2020, 25 ind., 26–165 mm; Station 13, 11.09.2019, 14 ind., 40–96 mm; St. 13, 13.07.2020, 2 ind., 28–32 mm.

***Carassius gibelio* (Bloch, 1782)**

Material examined: Station 1, 11.09.2019, 2 ind., 115-131 mm; St. 1, 19.05.2020, 3 ind., 104–125 mm; Station 2, 13.07.2020, 1 ind., 122 mm.

Family Leuciscidae

***Pseudorasbora parva* (Temminck & Schlegel, 1846)**

Material examined: Station 1, 11.09.2019, 10 ind., 40–70 mm; Station 2, 26.05.2020, 8 ind., 33–57 mm; St. 2, 13.07.2020, 7 ind., 20–68 mm; Station 3, 18.12.2020, 1 ind., 50 mm.

***Petroleuciscus borysthenicus* (Kessler, 1859)**

Material examined: Station 6, 11.09.2019, 37 ind., 26–86 mm; St. 6, 19.05.2020, 12 ind., 35–66 mm; St. 6, 24.05.2020, 12 ind., 47–80 mm; St. 6, 13.07.2020, 9 ind., 56–100 mm; St. 6, 01.01.2021, 16 ind., 39–62 mm; Station 8, 11.09.2019, 18 ind., 27–111 mm; Station 9, 08.06.2020, 1 ind., 39 mm; St. 9, 01.01.2021, 35 ind., 24–94 mm.

Family Poeciliidae

***Gambusia holbrooki* Girard, 1859**

Material examined: Station 2, 13.07.2020, 1 ind., 18 mm; Station 3, 11.09.2019, 38 ind., 11–30 mm; St. 3, 18.12.2020, 30 ind., 12–29 mm; Station 13, 11.09.2019, 84 individuals, 13–41 mm; St. 13, 13.07.2020, 5 ind., 18–50 mm; St. 13, 02.01.2021, 39 ind., 12–38 mm.

Family Mugilidae

***Chelon auratus* (Risso, 1810)**

Material examined: Station 3, 13.07.2020, 3 individuals, 43–47 mm.

The relative abundance (N%) and frequency of occurrence (F) values of each fish species per sampling site were shown in Table 3. Accordingly, it was determined that the nonnative fishes (*G. holbrooki* and *P. parva*) were frequently occurred in the most of the sampling sites, except for the native species *P. borysthenicus* living in Şahinkaya Reservoir and its tail waters. Moreover, the translocated species *C. carpio* was represented with a high value (100%) in Aydıncık and Dereköy Reservoirs since

Table 2. Number and length range (min-max) of specimens of each native, nonnative and translocated species caught in the sampling sites of Gökçeada Island.

Species	Localities									
	Gökçeada Reservoir	**Tepeköy Stream**	**Büyük Stream**	**Aydıncık Reservoir**	**Şahinkaya Reservoir**	**Çıkırım Stream-2**	**Çıkırım Stream-3**	**Dereköy Reservoir**	**Uğurlu Reservoir**	**Total**
Native species										
Anguilla anguilla			1 (603 mm)							**1**
Chelon auratus			3 (43–47 mm)							**3**
Petroleuciscus borysthenicus					86 (26–100 mm)	18 (27–111 mm)	36 (24–94 mm)			**140**
Nonnative species										
Carassius gibelio	5 (104–131 mm)	1 (122 mm)								**6**
Gambusia holbrooki		1 (18 mm)	68 (11–30 mm)						128 (12–50 mm)	**197**
Pseudorasbora parva	10 (40–70 mm)	15 (20–68 mm)	1 (50 mm)							**26**
Translocated species										
Atherina boyeri		2 (41–53 mm)								**2**
Cyprinus carpio	3 (81–161 mm)	1 (262 mm)		47 (21–100 mm)				51 (26–165 mm)	16 (28–96 mm)	**118**
Total	**18**	**20**	**73**	**47**	**86**	**18**	**36**	**51**	**144**	**493**

Table 3. Relative abundance (N%) and frequency of occurrence (F) values of each fish species at the sampling sites in Gökçeada Island.

Locality	Species	N (%)	F
Gökçeada Reservoir	*C. carpio*	16.67	0.17
	C. gibelio	27.78	0.17
	P. parva	55.56	0.17
Tepeköy Stream	*A. boyeri*	10.00	0.17
	C. carpio	5.00	0.17
	C. gibelio	5.00	0.17
	G. holbrooki	5.00	0.17
	P. parva	75.00	0.33
Büyük Stream	*A. anguilla*	1.37	0.17
	C. auratus	4.11	0.17
	G. holbrooki	93.15	0.33
	P. parva	1.37	0.17
Aydıncık Reservoir	*C. carpio*	100.00	0.50
Şahinkaya Reservoir	*P. borysthenicus*	100.00	0.50
Çıkırım Stream-2	*P. borysthenicus*	100.00	0.17
Çıkırım Stream-3	*P. borysthenicus*	100.00	0.17
Dereköy Reservoir	*C. carpio*	100.00	0.33
Uğurlu Reservoir	*C. carpio*	11.11	0.33
	G. holbrooki	88.89	0.50

it is the only fish species living in there. In addition, *G. holbrooki* is the most frequent fish species with the value calculated for Uğurlu Reservoir (Table 3).

4. Discussion

The primary factors leading to fish biodiversity loss are water pollution, habitat alteration and introduced species. Freshwater ichthyofauna of the Mediterranean basin involves a large number of endemic species, many of which are threatened with extinction (Myers et al., 2000). Because of the rapid spread of human-by, removal of natural physical barriers and artificial transport of species, bioinvasions have gone out-of-control and cause significant harm to habitats and species composition. As in other countries in the world, there is a growing concern in Turkey, especially in relation to the situation of invasive species today (Keskin et al., 2013). The introduction of alien species into new ecosystems causes local species living in these fields to be affected by this circumstance and these effects mostly result in a negative way. Accordingly, this study reports eight fish species (Table 2) in the lotic and lentic systems of Gökçeada Island, and three of them (*A. boyeri*, *C. gibelio* and *G. holbrooki*) are new occurrences of translocated/invasive fish species that may threaten the inland water ecosystem of the island. In addition, *C. carpio*, *G. holbrooki* and *P. parva* are the most common translocated/nonnative fish species for the studied localities with high values of relative abundances (Table 3).

The main factors for the introduction of invasive fishes to Turkey have been aquaculture and stocking activities to support fish farming, likewise commercial and recreational fishing (Innal and Erk'akan, 2006; Aydın et al., 2011). Common carp *Cyprinus carpio*, which is native to Central Asia and Eastern Europe (Troca et al., 2012), was introduced to the reservoirs of Turkey for the same purposes (Innal and Erk'akan, 2006). According to Şaşı and Berber (2012), fish stockings have been conducted in some reservoirs within the island and a total of 240,000 common carp *C. carpio* fingerlings were stocked to Aydıncık, Dereköy, Şahinkaya and Uğurlu Reservoirs. When compared with the findings of this study, common carp was found in all reservoirs where it was stocked, except Şahinkaya Reservoir. However, according to Ulutürk et al. (1986), a total of 76,500 common carp fingerlings were stocked to Şahinkaya Reservoir. Additionally, the local fishermen indicate that common carp was caught by other fishing gears (i.e. fishing rods, fish traps, gillnets) in the 2010s (personal interviews). The fact that the species is not occurring in Şahinkaya Reservoir today suggests the possibility that this fish could not hold on to the lake because it competes with the native fish *P. borysthenicus* for habitat and food as predicted in many previous studies (Bøhn et al., 2008; Martin et al., 2010; Copp et al., 2017; Ramler and Keckeis, 2019). Common carp was also found to occur both in Gökçeada Reservoir and its input stream (Tepeköy Stream) quite surely as result of fish stocking activities. Since the river sections at the input and output streams of other reservoirs dry up during the summer, no fish have been found in the other reservoirs except the output streams of Gökçeada and Şahinkaya Reservoirs.

In addition to the new occurrences of invasive freshwater fish in inland waters of Gökçeada Island, nonnative topmouth gudgeon *Pseudorasbora parva* was found in Gökçeada Reservoir, and also its input (Tepeköy Stream) and output (Büyük Stream) stream. Bakaç et al. (2017) have reported that topmouth gudgeon was found in the input stream of Gökçeada Reservoir and the presence of this species on the island was significant evidence of the expansion of these harmful species due to anthropogenic effects. Thus, topmouth gudgeon may have entered to Büyük Stream with the release of excess water from Gökçeada Reservoir. Topmouth gudgeon was reported in Turkey from the Thrace region for the first time in 1982 (Erk'akan, 1984). After entering Turkey, the most likely scenario of its spread within many water sources of the country is common carp restocking. It is

thought that this species has reached Gökçeada Reservoir accidentally through these activities and spread to the streams connected to the lake. The absence of *P. parva* in other reservoirs of the island yet does not mean that this species or any other translocated/invasive fish species will not be encountered in the future by means of stocking activities or accidental introductions.

This study has also reported three new occurrences of translocated/nonnative fish species that may threaten the inland water ecosystem of Gökçeada Island, Turkey's largest island and evaluate possible entry routes of these fishes. The occurrence of gibel carp *C. gibelio* can also derive by unintentional release in to Gökçeada Island during common carp restockings. Similar to the *P. parva*, *C. gibelio* was found only in Gökçeada Reservoir and its input water Tepeköy Stream. Such multiple introductions of gibel carp seem to be continuing through popular common carp introductions especially in newly created reservoirs throughout the country (Özuluğ et al., 2004; Önsoy et al., 2011; Tarkan et al., 2012). Natural spread through connected river systems (such as Meriç River) might have also been responsible for secondary nonnative dispersion of this species within Turkish freshwater bodies. These dispersal patterns acting together facilitated the spread of gibel carp all over the country.

The invasive eastern mosquitofish *G. holbrooki* has been successfully introduced into freshwater and brackish ecosystems throughout the world as a Malaria control agent (Pyke, 2005). *Gambusia holbrooki* was first introduced in Turkey in the 1930s with the purpose to control mosquitoes and avoid the spread of Malaria but now the species has spread throughout the country (Geldiay and Balık, 2009; Özuluğ et al., 2013; Kurtul and Sarı, 2019). Therefore, it is thought that *G. holbrooki* may has been introduced to Gökçeada Island for the same purpose. In the meantime, considering both the relative abundance and frequency of occurrence values (Table 3), *G. holbrooki* can be considered as the most threatening species for the ecosystem of Gökçeada Island among the nonnative fish species.

The coastal ecosystem of Gökçeada Island of the North Aegean Sea is very rich in terms of fish biodiversity. North Aegean Sea is an important fishing area besides being a feeding area for many fish species. Many economically important fish species, such as *Atherina boyeri*, exploited in this region use these coastal habitats to feed, reproduce, protect, and grow. This species has economic value; however, it is regarded as translocated/invasive species for the inland waters of Turkey. In recent years, it was introduced to many natural and artificial lakes in Turkey for fish stocking in those areas (Saç et al., 2015; Ünlü et al, 2017; Partal et al., 2019). Because of the wide variety of food and habitat preferences, this species is very well adapted to the environment it enters, grows rapidly and creates large populations. For this reason, the occurrence of *A. boyeri* in Tepeköy Stream, which is not connected directly to the sea, may be due to either its intentional stocking into Gökçeada Reservoir or by unintentional introduction due to the use of fishing nets that are also used in the sea.

Petroleuciscus borysthenicus is a small and short-lived freshwater fish. This species generally lives in slow flowing streams and lakes, however it can also survive in low salinity lagoons. Black Sea basin is the native area of this species and it is also distributed in Marmara, North Aegean and Eastern Black Sea regions in Turkey (Kottelat and Freyhof, 2007). It is distributed in the streams of Çanakkale and Meriç-Ergene river basin, which is close to Gökçeada Island. The occurrence of this species in Gökçeada was firstly reported in this study and, it was found only in Şahinkaya Reservoir and Çıkırım Stream. The survival of this species in the inland waters on the island can be threatened by a further spread of *C. carpio* or other fish species in Şahinkaya Reservoir. Since it is the only location where native fish *P. borysthenicus* exist in Gökçeada Island, it is recommended that do not make fish stocking activities in order to prevent nonnative species from entering Şahinkaya Reservoir and its basin. In addition, the use of irrigation water from the reservoir should be regulated and a minimum flow should be left in order to prevent drying in the stream section located to the downstream.

Chelon auratus is an economically important marine fish species, which can enter rivers individually or in groups to feed and to protect themselves from their predators. The occurrence of this and other mullet species in Gökçeada Island is not surprising given that its streams flow into the sea.

Anguilla anguilla is an endangered species (Critically Endangered-CR, see Pike et al., 2020), which spawns only once in its lifetime. This species, which lives almost its entire life in freshwaters, migrates to the sea when it reaches reproductive maturity. All European eels migrate to the Sargasso Sea for reproduction. After breeding, the juveniles follow the flows and they return to the inland waters (van Ginneken and Maes, 2005; Kottelat and Freyhof, 2007). The individuals of European eel are rarely encountered in the streams in Gökçeada Island. The occurrence of *A. anguilla* in inland waters of Gökçeada Island (Büyük Stream) is reported in this study for the first time since 1986 (Ulutürk et al., 1986). According to Ulutürk et al. (1986), a total of 200 European eels (650–785 mm) were found in Şahinkaya Reservoir between 1983 and 1985. Additionally, 1270 European eels (810–1245 mm) were reported in Dereköy Reservoir between 1983 and 1984. This species, which was frequently encountered

in the 1980s, is rarely seen in the inland waters today. This situation seems to be compatible with the extinction of this species worldwide because of habitat disintegrations and water pollution. On the other hand, before the dams were built on the streams on the island, European eels could reach the inner parts of the island. However, after construction of barrier and weirs, the species can only be found in the streams between the dams and the sea. There are no fish passages in the dams built on rivers that will allow European eels to migrate. It prevents juvenile eels to reach the inner parts of the island and it causes them to live in a very narrow area between the reservoirs and the sea.

Insular ecosystems are biodiversity hotspots especially for freshwater species (Schütte et al., 2018). In this context, according to Stoumboudi et al. (2006), four native freshwater fish species (*Knipowitschia caucasica*, *Oxynoemacheilus theophilii*, *Petroleuciscus smyrnaeus*, and *Squalius cii*), which inhabit Anatolian inland waters, and a nonnative freshwater fish (*Gambusia holbrooki*), were recorded on the Eastern Aegean Island of Lesbos (Greece). Comparing this study with the mentioned study, the number of native species identified in this study was less and nonnative species were more dominant. Because of the lack of literature on ichthyological studies of Gökçeada Island, we believe that the number of native freshwater fish species are limited by reason of introduced species or deterioration of stream continuity due to hydraulic structures such as reservoirs.

The nonnative fish species found in the inland waters of Gökçeada Island should be examined for their impacts on the food web, and the water quality in reservoirs. *Carassius gibelio* has unintentionally been translocated through *C. carpio* stockings (Aydın et al., 2011; Ağdamar and Tarkan, 2019) and was shown to establish more successful populations in stagnant inland waters. These two nonnative species are likely to compete for feeding and breeding zones, and *P. parva* may take advantage of this competition. Moreover, it is known that nonnative species can also over compete with native ones for feeding (Pompei et al., 2014). All these possibilities need to be monitored with future studies focusing on feeding and reproduction properties of these species. A further threat for native species can be the presence of parasites carried by the nonnative species. In the case of *Pseudorasbora parva*, for example, it was well reported that its associated parasite *Sphaerothecum destruens* have had negative impacts on the native fish species throughout North America and Europe (Gozlan et al., 2005; Ercan et al., 2015). Further studies to assess also the threat occurrence of this or other parasites by nonnative species detected in Gökçeada Island are suggested.

5. Conclusion

Currently, there are no detailed management actions or plan against the spread of nonnative fish species acting in Turkey. Though, some promising effort has been initiated by the competent authorities to prevent further spread and introductions to fragile ecosystems (e.g., island ecosystems). As eradication is almost impossible for these fish species and control is highly unlikely especially if they are not targets of commercial use and not harvested for that use, the most efficient measure seems to prevent further multiple introductions from different sources. Understanding the impacts of invasive fish species could be used in building up more effective management programs for nonnative species and conservation strategies for native fish species (e.g., the control of unauthorized stockings, regular monitoring, central information system). Accurate monitoring of the stock status of nonnative species found to occur in inland waters of Gökçeada Island, and their interactions with common carp and other aquatic biotas are needed.

Acknowledgements

This study was supported by the Research Fund of Çanakkale Onsekiz Mart University (Project No: FBA-2019-3007). This study was also conducted with the permission of Çanakkale Onsekiz Mart University Committee of Animal Experiments Local Ethics (Decision ID: 2019/03-03). The authors thank Sedat Ozan Güreşen for his kind helps during the field surveys. We thank Dr. Onur Gönülal for allowing us to use his personal library. We also thank İstanbul University, Faculty of Aquatic Sciences for facilitating the laboratory of Gökçeada Marine Research Unit.

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